

ETA-NTP004

Revision 2

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Electric Vehicle Constant Speed Range Tests

Prepared by

Electric Transportation Applications

Prepared by: _____
Ryan Harkins

Date: _____

Approved by: _____
Donald B. Karner

Date: _____

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1.0 Objective

The objective of this procedure is to identify proper methods for the control of constant speed range testing, as identified in SAE-J227a (canceled). These methods are not meant to supersede those of the testing facility, those specifically addressed by SAE Test Standards, nor of any regulatory agency who may have or exercise control over the covered activities.

2.0 Purpose

The purpose of this procedure is to identify acceptable methods for the implementation of a constant speed range test, similar to that identified in SAE J227a (canceled). The SAE J227a Recommended Practice, although canceled, established uniform procedures for testing electric battery-powered vehicles as a total system rather than a collection of its individual subsystems. This procedure shall collect and retain test data as specified in the NEV America Technical Requirements.

3.0 Documentation

Documentation addressed by this procedure shall be consistent, easy to understand, easy to read and readily reproducible. This documentation shall contain enough information to "stand alone"; that is, be self-contained to the extent that all individuals qualified to review it could be reasonably expected to reach a common conclusion, without the need to review additional documentation. Review and approval of test documentation shall be in accordance with ETA-NAC004, "Review of Test Results." Storage and retention of records during and following testing activities shall be completed as described in Procedure ETA-NAC001, "Control, Close-out and Storage of Documentation."

4.0 Initial Conditions and Prerequisites

Prior to conduct of any portion of the testing, the following initial conditions and prerequisites shall be met. Satisfactory completion of these items shall be verified as complete and recorded on the Constant Speed Range Test Data Sheet.

- 4.1 Personnel conducting testing under this procedure shall be familiar with the requirements of this procedure, and when applicable the appropriate SAE Test Instructions, Administrative Control Procedures, and be certified by the Program Manager, Test Manager or specific Test Engineer prior to commencing any testing activities.

- 4.2 All documentation required to complete the testing shall be completed, approved and issued (past its effective date) prior to commencing the testing it addresses.
- 4.3 Road Testing
 - 4.3.1 Road tests shall be performed on a road or test track which is level to within 1%.

NOTE

Vehicles should be capable of standing for extended periods in extreme temperatures without danger of damage or failure of the vehicle or its systems. This includes ambient air temperatures of 0-120°F, paved surface temperatures of greater than 150°F, and occupant compartment temperatures in excess of 170°F.

- 4.3.2 Battery temperatures at the beginning of the test shall be between 59°F and 100°F (15°C to 38°C).
 - 4.3.3 Ambient temperature during road testing shall be within the range of 40°F to 120°F (5°C to 49°C).
 - 4.3.4 The recorded average wind speed at the test site during the test shall not exceed 10 mph (16 km/h).
- 4.4 Vehicle shall be tested in its normal configuration with normal appendages (mirrors, bumpers, hubcaps, etc.). Certain items (hubcaps, etc.) may be removed where necessary for safety.
- 4.5 Vehicles shall be tested at curb weight plus 332 pounds. Consideration should be given to how adding instrumentation will affect the test weight and balance of the vehicle.
- 4.6 Tires shall be inflated to the recommended (placard) cold inflation pressures. This pressure shall not exceed the maximum allowable pressure imprinted upon the tire's sidewall.
- 4.7 Vehicle supplier's recommended lubricants shall be employed.
- 4.8 Accessories shall not be used during testing activities.
- 4.9 Full charge conditions for the main propulsion batteries shall be established using the manufacturer's recommended charging procedure and equipment in accordance with ETA-NTP008, "Battery Charging."

- 4.10 The following data shall be collected during conduct of the various tests specified by this procedure. Overall error in recording or indicating instruments shall not exceed $\pm 2\%$ of the maximum value of the variable being measured. Periodic calibration shall be performed and documented to ensure compliance with this requirement.
 - 4.10.1 Battery voltage versus time;
 - 4.10.2 Battery current versus time;
 - 4.10.3 Vehicle speed versus time;
 - 4.10.4 Distance versus time;
 - 4.10.5 Battery temperature versus time;
 - 4.10.6 Battery watts versus time;
- 4.11 Environmental conditions during the testing shall be recorded and include, at a minimum, the following:
 - 4.11.1 Range of ambient temperature during the test;
 - 4.11.2 Range of wind velocity during the test;
 - 4.11.3 Range of wind direction during the test.
- 4.12 Verify that Procedures ETA-NAC006, "Vehicle Verification," and ETA-NTP011, "Receipt Inspection," have been completed.
- 4.13 A description of the test route, road-surface type and condition (SAE J688), and lengths and grades of test route, shall be recorded.
- 4.14 The date and starting and ending times shall be recorded.
- 4.15 The starting and ending vehicle odometer readings shall be recorded.
- 4.16 All instrumentation used in the test shall be listed on Appendix C, attached to the test data sheets/results, and shall include the following information:
 - 4.16.1 Manufacturer
 - 4.16.2 Model Number
 - 4.16.3 Serial Number
 - 4.16.4 Last Calibration date
 - 4.16.5 Next Calibration date
- 4.17 The speed-time measuring device and other necessary equipment shall be installed so that they do not hinder vehicle operation or alter the operating characteristics of the vehicle. Mounting will nominally be at the rear of the vehicle.
- 4.18 Any deviation from the test procedure and the reason for the deviation, shall be recorded in accordance with ETA-NAC002.

- 4.19 All documentation required to complete the testing shall be completed, approved and issued prior to commencing the testing it addresses.
- 4.20 During data reduction, the actual distance traveled and the corresponding DC Energy consumption shall be determined. These values are the 100% SOC mileage and energy meter reading. These values shall be used throughout the remainder of testing, and shall be the basis for determining SOC is less than 100%.
- 4.21 In addition to the formal completion of all sections of this procedure, Section 5.1 may be completed at additional times as requested by the ETA Program Manager or ETA Test Manager. [Additional tests may be completed to determine changes to the range capability of a vehicle, or if a vehicle's permanently installed instrumentation is suspected of misoperation.
- 4.22 Each Range Test shall be terminated when the specific requirements of the sub-section have been reached. However, if the manufacturer's instructions provide guidance about when to stop driving the vehicle, the vehicle's range will be the range achieved when the conditions meeting that guidance have occurred. [Example: If the owner's manual/driver's instructions provided with the vehicle provide direction to stop driving upon receipt of a specific telltale or other indication normally available to the driver, the vehicle will be stopped and the test terminated when that telltale/indication has occurred.]

5.0 Testing Activities Requirements

NOTE

All steps shall be completed in the order written. Deviations from any step or requirement shall have the approval of the Program Manager or Test Manager in accordance with Procedure ETA-NAC002, "Control of Test Conduct."

5.1 Range at Maximum Attainable Constant Speed

The purpose of this section is to (1) Determine the maximum range the vehicle can achieve with the batteries fully charged (100% SOC), the vehicle loaded at curb weight plus 332 pounds, and operated at a constant top speed; (2) determine the correlation between the State of Charge indicator (if so equipped) and the mileage driven (which will be used to establish partial SOC conditions in other protocols); and (3) verify accuracy of the vehicle odometer. Vehicles should have a minimum range

between charges of at least 25 miles when loaded with two 166-pound occupants (or equivalent) and operated at constant top speed.

This testing shall be completed subject to the initial conditions and prerequisites stated in Section 4 of this procedure.

- 5.1.1 Instrument the vehicle to obtain, at a minimum, the data identified in Section 4.10. Calibrate the fifth wheel, as necessary.
- 5.1.2 Verify the traction battery is at fully charged (100% SOC).
- 5.1.3 Record time and the vehicle's odometer reading on Appendix A.
- 5.1.4 Adjust the vehicle's cold tire pressures to match the manufacturer's placard value, or the maximum cold inflation pressure imprinted upon the tire's sidewall, whichever is less.
- 5.1.5 From a standing start, accelerate the vehicle under its own power to its maximum top speed ± 1 mph (± 1.6 km/h). Speed and time may be recorded via a Data Acquisition System (DAS).
- 5.1.6 Each time the vehicle passes the lap marker, record the SOC meter reading (if so equipped) and the odometer reading on Appendix D. Each reading shall be recorded in the smallest increment displayed by its respective indicator.

NOTE

All vehicles tested will be operated in accordance with the requirements of the manufacturer's operating manuals/instruction cards/placards. Should the manufacturer's requirements for stopping the vehicle be met prior to reaching the criteria in Step 5.1.7, the test shall be terminated. The Official Range will be the range achieved at that point, regardless of remaining capability.

- 5.1.7 Maintain maximum speed without interruption until the indication of battery maximum depth of discharge described in the Owner's Manual has been reached or an average vehicle lap speed of at least 19 mph (30 km/h) cannot be maintained (either from low battery voltage or from power limit by the vehicle motor. If testing is being accomplished at Exponent FaAA, continue testing until the vehicle will not maintain 18 mph on the east bound straight-away. Record the final speed, test termination criteria and time on Appendix A. (This may be recorded via a DAS.)

- 5.1.8 Pull the vehicle off to the side of the test track. Record the time, mileage, SOC meter, and odometer reading on Appendix D. (Time may be recorded via a DAS.)
- 5.1.9 The mileage achieved during this test shall be recorded as the official range mileage for the vehicle being tested.
- 5.1.10 The difference in the odometer readings from the start of the test to the completion of the test shall be recorded in Appendix A. This distance shall be compared with the distance traveled, as indicated by the DAS. The accuracy of the odometer shall be verified to be at least $\pm 5\%$.
- 5.1.11 From battery voltage and current data collected by the DAS, calculate the difference between the depth of discharge reached in Section 5.1.7 and the vehicle supplier's recommended maximum depth of discharge as provided in NEV America Vehicle Technical Specification Appendix A and record on Appendix A.
- 5.1.12 From battery voltage and current data collected by the DAS, record the actual battery SOC for each Odometer/Vehicle Display SOC entry on Appendix D.
- 5.1.13 Using data from Appendix D, calculate the kWh or Ah to be discharged from full charge (as defined in ETA-NTP008 Section 5.1) to achieve 50% SOC for use in subsequent testing.

5.2 Calibration of the Vehicle Speedometer

This section should be completed concurrent with completion of ETA-NAC006, "Vehicle Verification" as well as in conjunction with Sections 5.1 of this procedure. It may also be implemented any time the speedometer is suspected of mis-operation. If the calibration is being completed independent of range testing, do not complete steps 5.2.1, 5.2.2 or 5.2.3.

- 5.2.1 When accelerating the vehicle to a predetermined speed, record the vehicle speedometer reading compared to the installed Data Acquisition System (DAS) speed reading, in 5 mph increments, up to and including the final speed achieved. [To promote safety, this may be done verbally by speaking to a tape recorder, and then later transcribed into Appendix B.]
- 5.2.2 The error between the speedometer and the DAS readout shall be calculated and the results posted in the vehicle for the driver to use.
- 5.2.3 If the driver notices a difference between the indicated value and the calculated correction factor, this test should be run again.

- 5.2.4 If the vehicle is being operated for the sole purpose of calibrating the speedometer, calibration should be as follows:
 - 5.2.4.1 Ensure the vehicle is instrumented with a DAS.
 - 5.2.4.2 With the vehicle stopped, record the speedometer reading.
 - 5.2.4.3 Accelerate the vehicle to 5 mph; record the speedometer reading and the DAS heads-up display speed readout.
 - 5.2.4.4 Increase vehicle speed in 5-mph increments, recording the speedometer and heads-up display speed read-out at each speed. Continue this until the vehicle has achieved its maximum speed.
 - 5.2.4.5 Verify the speedometer accuracy is at least $\pm 5\%$ at 20 mph and develop a calibration reference table, Appendix B, for the speedometer.
 - 5.2.4.6 Mount the calibration reference table in the subject vehicle adjacent to the speedometer.

6.0 GLOSSARY

- 6.1 Battery kilowatt-hour (kWh) Capacity - The capacity of a battery in kilowatt-hours determined as a function of the total distance traveled by the vehicle during performance of the Constant Speed Range Test portion of ETA-NTP004.
- 6.2 Curb Weight - The total weight of the vehicle including batteries, lubricants, and other expendable supplies but excluding the driver, passengers, and other payloads.
- 6.3 Effective Date - The date, after which a procedure has been reviewed and approved, that the procedure can be utilized in the field for official testing.
- 6.4 Fifth Wheel - A calibrated mechanical instrument used to measure a vehicle's speed and distance independent of the vehicles on-board systems.
- 6.5 Gross Vehicle Weight Rating (GVWR) - The maximum design loaded weight of the vehicle specified by the manufacturer.
- 6.6 Initial Conditions - Conditions that shall exist prior to an event occurring.
- 6.7 Initial State of Charge (SOC) - Initial State of Charge is the SOC at the beginning of a test. It does not have to be 100%.
- 6.8 Prerequisites - Requirements that must be met or resolved prior to an event occurring.

- 6.9 Program Manager - As used in this procedure, the individual within Electric Transportation Applications responsible for oversight of the NEV America Performance Test Program. [Subcontract organizations may have similarly titled individuals, but they are not addressed by this procedure.]
- 6.10 Shall - This word is used to indicate an item which requires adherence without deviation. Shall statements identify binding requirements. A go, no-go criterion.
- 6.11 Should - This word is used to identify an item which requires adherence if at all possible. Should statements identify preferred conditions.
- 6.12 State of Charge (SOC) - For this testing, the SOC of a battery is defined as the expected residual battery capacity, expressed in amperes-hours or watt-hours or miles, as a percentage of the total available. The 100% SOC basis (available ampere-hours, kilowatt-hours or miles) is determined by the actual discharge capability of the main propulsion battery when discharged to the requirements of the Constant Speed Range Test portion of procedure ETA-NTP004.
- 6.13 Test Director - The individual within Electric Transportation Applications responsible for all testing activities associated with the NEV America Performance Test Program.
- 6.14 Test Director's Log - A daily diary kept by the Test Director, Program Manager, Test Manager or Test Engineer to document major activities and decisions that occur during the conduct of a Performance Test Evaluation Program. This log is normally a running commentary, utilizing timed and dated entries to document the day's activities. This log is edited to develop the Daily Test Log published with the final report for each vehicle.
- 6.15 Test Engineer - The individual(s) assigned responsibility for the conduct of any given test. [Each contractor/subcontractor should have at least one individual filling this position. If so, they shall be responsible for adhering to the requirements of this procedure.]
- 6.16 Test Manager - The individual within Electric Transportation Applications responsible for the implementation of the test program for any given vehicle(s) being evaluated to the requirements of the NEV America Performance Test Program. [Subcontract organizations may have similarly titled individuals, but they are not addressed by this procedure.]

7.0 REFERENCES

- 7.1 NEV America Vehicle Technical Specification
Revision 1 dated April 15, 2002
- 7.2 ETA-NAC001 - "Control, Close-out and Storage of Documentation"
- 7.3 ETA-NAC002 - "Control of Test Conduct"
- 7.4 ETA-NAC004 - "Review of Test Results"
- 7.5 ETA-NAC006 - "Vehicle Receipt"
- 7.6 ETA-NAC007 - "Control of Measuring and Test Equipment"
- 7.7 ETA-NTP002 - "Implementation of SAE Standard J1666 May 93, Electric Vehicle Acceleration, Gradeability and Deceleration Test Procedure"
- 7.9 ETA-NTP005 - "Electric Vehicle Rough Road Course"
- 7.10 ETA-NTP008 - "Battery Charging"
- 7.11 ETA-NTP011 - "Receipt Verification"
- 7.12 SAE Standard J227a

APPENDIX-A
Constant Speed Range Test
Data Sheet
(Page 1 of 2)

VIN: _____

Project No.:	Test Date(s):
Root File No.:	
Test Driver:	
(Initials)	(Date)
Test Engineer:	
(Initials)	(Date)

Vehicle Setup

VEHICLE WEIGHTS AS TESTED WITH DRIVER & INSTRUMENTATION (Curb weight plus 332 pounds)			
Left Front:	Right Front:	Total Front:	Percent Front: %
(lbs or kg)	(lbs or kg)	(lbs or kg)	
Left Rear:	Right Rear:	Total Rear:	Percent Rear: %
(lbs or kg)	(lbs or kg)	(lbs or kg)	
		Total Weight:	
		(lbs or kg)	
INSTALLED TIRES (Placard or sidewall whichever is less)			
Preparation Area Temperature:			
(°F or °C)			
Left Front		Right Front	
Pressure:		Pressure:	
(psi or kPa)		(psi or kPa)	
Left Rear		Right Rear	
Pressure:		Pressure:	
(psi or kPa)		(psi or kPa)	

Track/Weather Conditions

Test Track Location:	Track Grade: %
Ambient Temperature (initial):	Ambient Temperature (final):
(40-100°F or 5-38°C)	(40-100°F or 5-38°C)
Track Surface Temperature (initial):	Track Surface Temperature (final):
(°F or °C)	(°F or °C)
Wind Velocity (initial):	Wind Velocity (final):
(<10 mph or 16 km/h)	(<10 mph or 16 km/h)
Wind Direction (initial): °	Wind Direction (completion): °

APPENDIX-A

Constant Speed Range Test Data Sheet (Page 2 of 2)

Test Data Sheet

Sequence No:		File No.:		Direction of Travel:	
Time (initial):			Time (final):		
Odometer (initial): <small>(miles or kilometers)</small>			Odometer (final): <small>(miles or kilometers)</small>		
Status of Charge (initial): <small>(SOC,kWh,Ah)</small>			Status of Charge (final): <small>(SOC,kWh,Ah)</small>		
Battery Temp (initial): <small>(°F or °C)</small>			Battery Temp (final): <small>(°F or °C)</small>		
Termination Criteria: <input type="checkbox"/> Indication <input type="checkbox"/> Speed Not Maintained <input type="checkbox"/> Discharge Power Limited					
DAS Termination DOD: _____% _____Ah					
Recommended Maximum DOD: _____% _____Ah					
Deviation Between Actual And Recommended Maximum DOD: _____%					
Comments (initials/date): _____ _____ _____ _____ _____ _____ _____ _____ _____ _____ _____ _____ _____ _____ _____ _____ _____ _____ _____					
Completed By: <div style="display: flex; justify-content: space-between;"><div>(Printed Name)</div><div>(Signature)</div><div>(Date)</div></div>					
Reviewed By: <div style="display: flex; justify-content: space-between;"><div>(Printed Name)</div><div>(Signature)</div><div>(Date)</div></div>					
Approved By: <div style="display: flex; justify-content: space-between;"><div>(Printed Name)</div><div>(Signature)</div><div>(Date)</div></div>					

APPENDIX-B
Calibration of Vehicle Speedometer
Test Data Sheet
(Page 1 of 1)

Vehicle Number: _____

Sequence No:	File No.:	Direction of Travel:
Time (initial):		Time (final):
Odometer (initial): <small>(miles or kilometers)</small>		Odometer (final): <small>(miles or kilometers)</small>
Status of Charge (initial): <small>(SOC,KWH,AH)</small>		Status of Charge (final): <small>(SOC,KWH,AH)</small>
DAS Heads-up Display:		Vehicle Speedometer:
0 MPH		
5 MPH		
10 MPH		
15 MPH		
20 MPH ($\pm 5\%$ accuracy)		
25 MPH		
Comments (initials/date): <hr/> <hr/> <hr/> <hr/> <hr/> <hr/> <hr/> <hr/> <hr/> <hr/>		
Completed By: _____ <small>(Printed Name) (Signature) (Date)</small>		
Reviewed By: _____ <small>(Printed Name) (Signature) (Date)</small>		
Approved By: _____ <small>(Printed Name) (Signature) (Date)</small>		

APPENDIX-C

Vehicle Metrology Setup Sheets

(Page 1 of 1)

Vehicle Number: _____

Instrument/Device:	Calibration Due Date:	Initials / Date:
Fifth Wheel S/N:		
Fifth Wheel Calibrator S/N:		
DAQ S/N:		
DAQ Set-up Sheet S/N		
kWh Meter S/N:		
Shunt S/N:		
Tire Pressure Gauge S/N:		
Accelerometer:		
Misc:		
Misc:		
Misc:		
Comments (initials/date):		
Completed By: _____ <div style="display: flex; justify-content: space-between; font-size: small;"> (Printed Name) (Signature) (Date) </div>		
Reviewed By (QA): _____ <div style="display: flex; justify-content: space-between; font-size: small;"> (Printed Name) (Signature) (Date) </div>		
Approved By: _____ <div style="display: flex; justify-content: space-between; font-size: small;"> (Printed Name) (Signature) (Date) </div>		

APPENDIX D
Calibration of Vehicle SOC Indicator
Test Data Sheet
(Page 1 of 1)

Vehicle Number: _____

Sequence No:	File No.:	Direction of Travel:
Time (initial):		Time (final):
Odometer (initial): <small>(miles or kilometers)</small>		Odometer (final): <small>(miles or kilometers)</small>
Status of Charge (initial): <small>(SOC,KWH,AH)</small>		Status of Charge (final): <small>(SOC,KWH,AH)</small>
VEHICLE STATE OF CHARGE (SOC)		
Odometer	DAS SOC (%)	Vehicle Displayed SOC
Comments (initials/date):		
Completed By:		
<small>(Printed Name)</small>	<small>(Signature)</small>	<small>(Date)</small>
Reviewed By:		
<small>(Printed Name)</small>	<small>(Signature)</small>	<small>(Date)</small>
Approved By:		
<small>(Printed Name)</small>	<small>(Signature)</small>	<small>(Date)</small>